



SHORT ORIGINAL ARTICLE / Cardiovascular imaging

# Iatrogenic cardiac perforation due to pacing lead displacement: Imaging findings



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## KEYWORDS

Perforation;  
Cardiac;  
Pacemaker;  
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Computed  
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## Abstract

**Purpose:** Cardiac perforations due to pacing and implantable defibrillator lead displacement are rare and their detection may be difficult. The goal of this study was to review the clinical and imaging presentation of cardiac perforation related to pacing lead displacement.

**Patients and methods:** The clinical and imaging files of four patients (two men and two women) who experienced cardiac perforation related to pacing lead displacement were reviewed. The four patients were investigated in our radiology department over a 24-month-period.

**Results:** Two patients had clinical symptoms at the time lead displacement was detected and the other two were free of symptoms. In all patients, lead displacement was visible on imaging examinations in retrospect but was not detected prospectively.

**Conclusion:** Radiologists should pay attention to the position of the tips of the leads on chest X-ray and CT, even late after the implantation and in asymptomatic patients.

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Cardiac perforations due to pacing lead displacement are rare, occurring in around 0.1–1% of cases for pacemakers and in 0.6–5.2% of cases for defibrillators [1]. They are particularly rare when they occur late after implantation of the device (more than 30 days after the procedure). The diagnosis is generally made upon the six monthly check on the device and the displacement can be confirmed by imaging, which provides information about the site of the displaced lead. In other circumstances, and particularly in emergency situations, imaging is performed before the cardiology assessment and it is up to the radiologist to suggest the diagnosis.

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The goal of this study was to review the clinical and imaging presentation of cardiac perforation related to pacing lead displacement.

## Patients and methods

We retrospectively reviewed all the cases of cardiac perforation related to pacing lead displacement tagged in our Picture Archiving and Communication System (Carestream Vue version 11.4.0.1253; Carestream Health, Inc., Toronto, Canada) and matching the key words "perforation" and/or "heart" and/or "cardiac" and/or "lead" over a 24-month-period (between August 2011 and September 2013 inclusively).

Clinical and all available imaging files were reviewed for all patients.

## Results

### Patient 1

A 24-year-old woman presented to the emergency department with respiration-dependent left basal chest pain, which had developed three days previously and was associated with breathlessness. She had neither cough nor fever. Her past history included catecholaminergic tachycardia for which a single chamber automatic defibrillator had been implanted three years previously. The defibrillation lead had been replaced six weeks prior to her presentation (active fixation lead) because of malfunction and the post-implantation cardiology review found no abnormality. Based on her clinical presentation, the recent history of the procedure and raised D-dimers (1239 ng/mL [normal value < 500 ng/mL] with a CRP of 7 mg/L [normal value < 10 mg/L]), an inspiration and expiration X-ray was performed followed by a chest CT angiogram.

The chest X-ray showed no gaseous pleural detachment. In retrospect, the pacing lead was found to have been displaced compared to the post-procedure investigation performed six weeks previously and she had a small left pleural effusion (Fig. 1).

CT angiogram showed no enhancement defect in the pulmonary arteries although in retrospect the end of the pacing lead was found to have perforated the myocardium and pericardium, passing 28 mm outside of the myocardium and coming into contact with the anterior arch of the 5th left rib. She had a moderate left sided pleural effusion but no pericardial effusion. After returning home following her consultation at the emergency department the patient was recalled after the CT angiogram had been reread. Patient condition ultimately improved after extracting the displaced lead and inserting a new one.

Also in retrospect, the tip of the lead already appeared to be incorrectly positioned on the post-implantation lateral film, projecting unusually forwards.

### Patient 2

A 33-year-old man presented to cardiology for routine follow up of a dual chamber pacemaker with active fixation leads

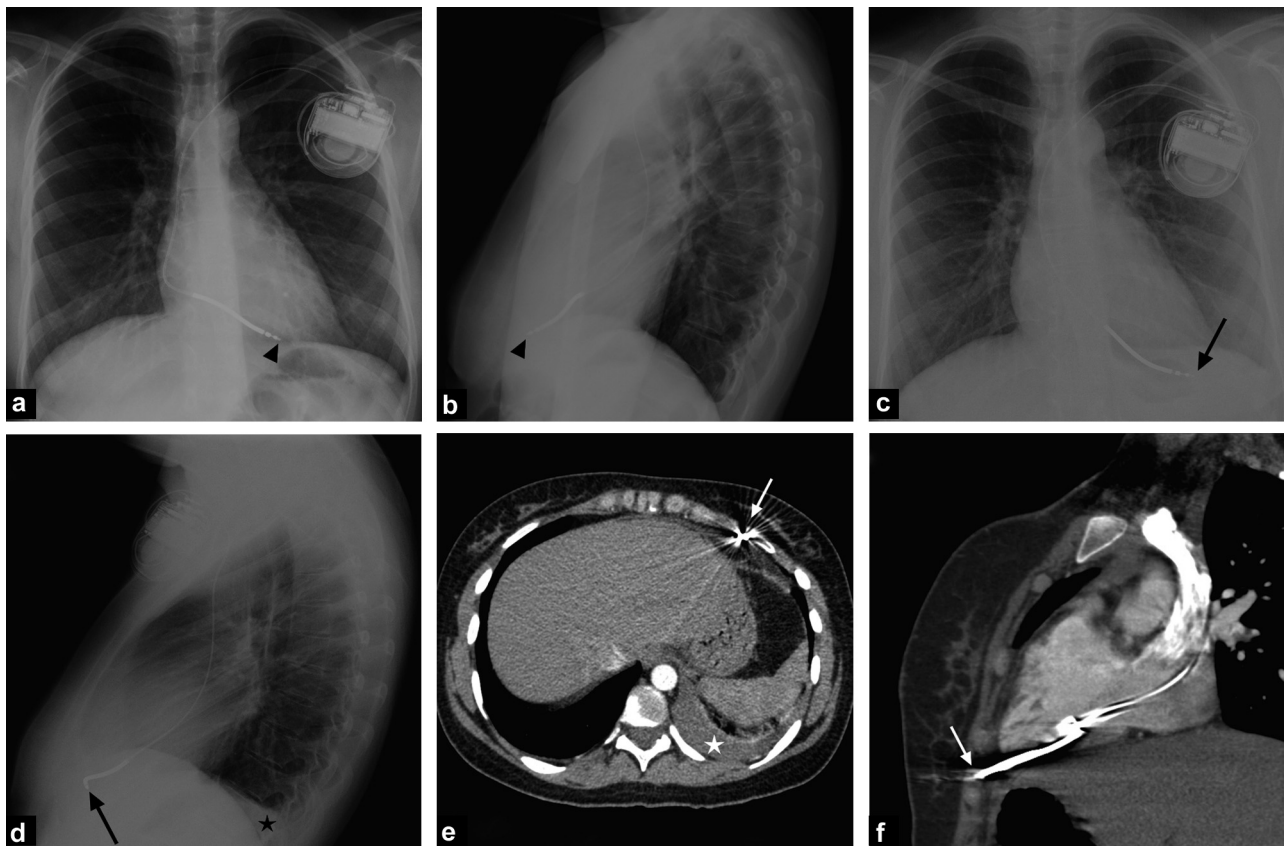
implanted nine months previously for paroxysmal complete atrioventricular block (Fig. 2). The patient was free of any symptoms. When the device was checked the cardiologist found defective capture and sensing in the right atrial lead, which was reprogrammed. He was then offered a further follow up evaluation at six months. Later during the day, the radiologist interpreted the chest X-ray and found that the right atrial lead was abnormally positioned. The patient was recalled for a chest CT with cardiac synchronization, which confirmed that the tip of the lead had perforated and entered over 2 cm into the middle lobe of the lung. He had neither pericardial nor pleural effusion, nor ground glass nor consolidation in the lung parenchyma. The patient had a favorable outcome after the displaced lead was removed.

### Patient 3

A 62-year-old man who had had a focal atrial tachycardia ablated from his left atrium four years previously was admitted to the emergency department in another hospital with palpitations. His electrocardiogram (ECG) showed a re-entry tachycardia of over 200 beats/minute, which was treated with verapamil. Shortly afterwards, the patient developed a very slow bradycardia with long pauses which required a temporary external pacemaker to be inserted and he was then transferred to our hospital for radiofrequency ablation of the cardiac arrhythmia. His pre-procedure cardiac CT angiogram showed perforation of the apex of the right ventricle with displacement of the lead more than 6 cm outside of the myocardium, the tip of the lead coming into contact with the diaphragm (Fig. 3). This perforation could not have been suspected from the chest X-ray, which was performed at the patient's bedside. The patient improved after removal of the temporary lead and radiofrequency ablation.

### Patient 4

A 69-year-old woman was referred to the emergency department by her general practitioner because of worsening of clinical condition, abdominal pain and grade IV dyspnea. The patient had past history including atrial disease (alternating sinus pauses and episodes of tachyarrhythmia on a Holter ECG) for which a pacemaker had been implanted three months previously (Fig. 4). An outpatient blood sample showed a severe acute phase reaction with acute renal failure, hepatic changes and vitamin K antagonist (VKA) overdosage, with an INR > 7. As a result of her clinical presentation, an acute abdominal condition with secondary dyspnea was first considered and an unenhanced abdominal CT (not enhanced because of her renal failure) which was performed before the chest X-ray showed firstly acute cholecystitis and secondly a large hemopericardium. Abdominal ultrasonography confirmed acute cholecystitis and also showed signs of a cardiac liver. The patient was then directly transferred to the cardiology intensive care unit where an echocardiogram confirmed a large pericardial effusion with severe impact on the cardiac cavities. Nine hundred and fifty mL of serous-bloody pericardial fluid were aspirated followed by improvement in cardiorespiratory status. One week later, cardiac CT angiogram confirmed displacement of the lead, the tip of which had penetrated the



**Figure 1.** Thirty-four-year-old female patient complaining of left basal chest pain. a: postero-anterior chest X-ray the day after replacing the defibrillator lead. No complications are seen and the lead appears to be correctly positioned (arrowhead); b: lateral chest X-ray performed on the same day. In retrospect the tip of the lead appears to lie too anteriorly (arrowhead). Note the projection of the arm over the cardio-mediastinal shadow; c and d: postero-anterior (in inspiration) and lateral chest X-ray six weeks later in the emergency department. Displacement of the pacing lead can be seen compared to the previous investigation on both views with a more tortuous appearance of the tip of the lead on the lateral film. The exact site of the end of the lead cannot however be identified (arrows). This is combined with a small left pleural effusion (star); e: chest CT angiogram without cardiac synchronization showing a myocardial perforation by the pacing lead, the end of which has come into contact with the anterior arch of the 5th left rib (arrow). Note the associated left pleural effusion (white star); f: multiplanar reconstruction along the axis of the pacing lead showing its displacement 28 mm outside of the myocardium (arrow).

epicardial fat by more than 8 mm with complete resolution of the pericardial effusion. In retrospect, the lead already appeared incorrectly positioned on the post-implantation investigation performed three months previously, projecting unusually low beneath the left hemi diaphragm. Following this episode the patient's VKA was stopped and replaced with aspirin. The displaced lead was not removed because of the patient's co-morbidities and she improved, with a satisfactory pacemaker check two years after the acute episode. The cholecystitis was treated medically and also improved.

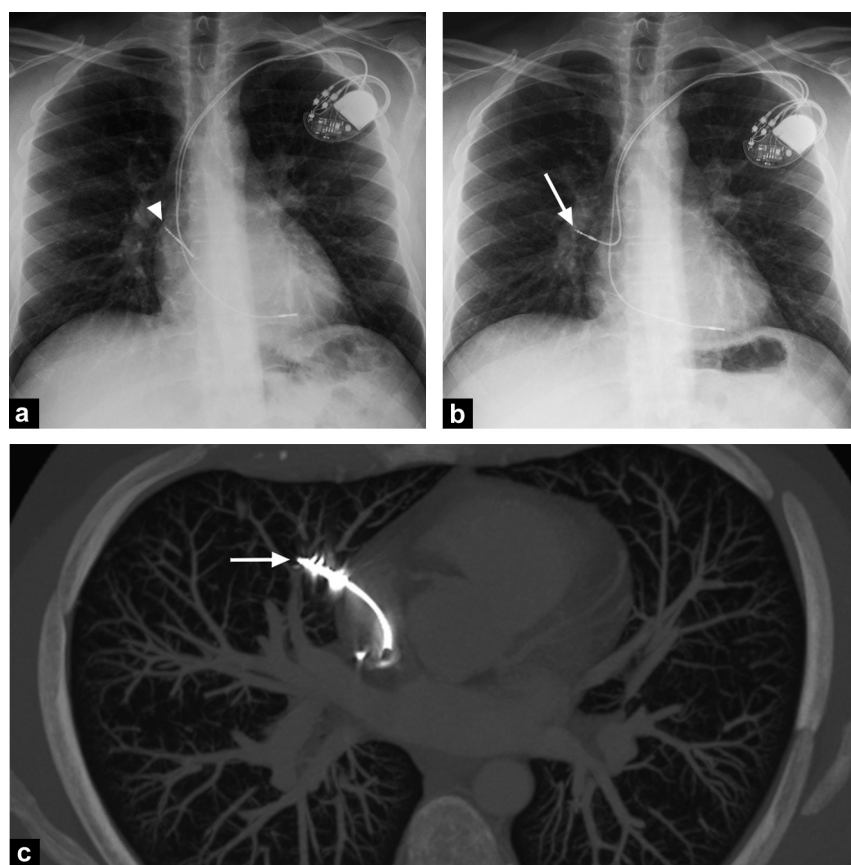
## Discussion

These four cases highlight the difficulties these perforations raise both for the clinician (the relatively non-specific clinical features or even asymptomatic nature of the perforation, possibly developing late after implantation of the device) and the radiologist (comparison with previous investigations is not performed routinely, limited attention paid to the pacing materials on both X-ray and CT, and delay in diagnosis).

It is estimated that over 60,000 and 14,000 pacemakers and cardiac defibrillators are implanted annually in France [2,3]. The corresponding figures in Belgium are around 10,000 pacemakers and 2000 defibrillators [4,5].

Cardiac pacemaker lead complications occur in 3.9 to 9.6% of implantations depending on the series [1]. Perforations by leads are rare, developing in the region of 0.1–1% of cases for pacemakers and 0.6–5.2% for defibrillators [1]. Perforation is described as acute, subacute, or chronic (late) depending on the time to onset of symptoms: acute when they occur within 24 hours and chronic when they occur more than 30 days after implantation [6]. Subacute and chronic perforations are rarer and often missed [1].

Clinical findings include chest pain, dyspnea, hypotension or syncope. They are relatively non-specific and depend on the site of the displaced lead (pericardium, pleural space, lung parenchyma or chest wall): The clinical course may be dramatic if tamponade or massive hemothorax occurs and may ultimately be fatal. Inappropriate electrical stimulation of the chest wall muscle or diaphragm may also occur and occasional cases of perforation have been described presenting with hiccups [7]. The perforation may also be



**Figure 2.** Asymptomatic 33-year-old man (patient 2): a: postero-anterior chest X-ray post-implantation showing the tip of the atrial lead projecting from the right atrium (arrowhead); b: investigation performed six months later during a routine follow up consultation showing displacement of the atrial lead which projects into the right hilum (arrow); c: chest CT angiogram with cardiac synchronization with *maximum intensity projection* (MIP) reconstruction confirming cardiac perforation by the lead, the tip of which is located over 2 cm in the middle lobe parenchyma (arrow). Note that neither a pericardial or pleural effusion, ground glass appearances or consolidation are present in the parenchyma in contact with the lead.

asymptomatic. Hirschl et al. reviewed 100 chest CT examinations in asymptomatic patients with implantable cardiac devices and found perforation in 15% of cases, more commonly with atrial (15% of atrial leads) than ventricular leads (6% of ventricular leads) [8]. Perforations due to right ventricular leads occurred significantly more often with defibrillators (14%) than with pacemakers (3%).

The risk factors for perforation are the use of active fixation leads, concomitant transvenous pacing, corticosteroid therapy, anticoagulation, female sex and a body mass index of under 20 kg/m<sup>2</sup> [1].

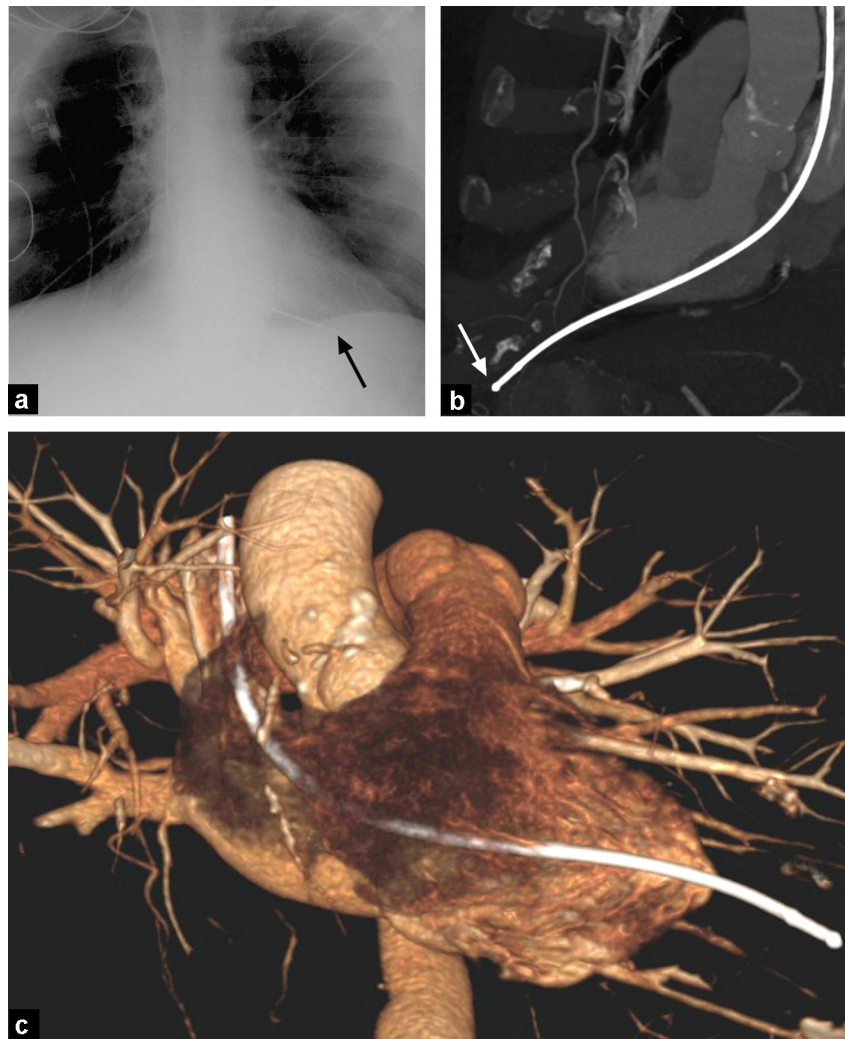
A cardiology review of the device (interrogating the instrument using a timer with telemetry) may find abnormalities, which have developed compared to the previous check, suggesting displacement of the lead. Normal parameters, however, do not exclude perforation [8]. Echocardiography may show the tip of the displaced lead and a pericardial effusion when this is present but may also be non-contributory [9].

The diagnosis is made more from imaging than from clinical features or a cardiology assessment. A perforation should be suspected on a chest X-ray if the lead is abnormally positioned, generally more caudal than usual for ventricular leads [10]. Films should be examined for a pleural or

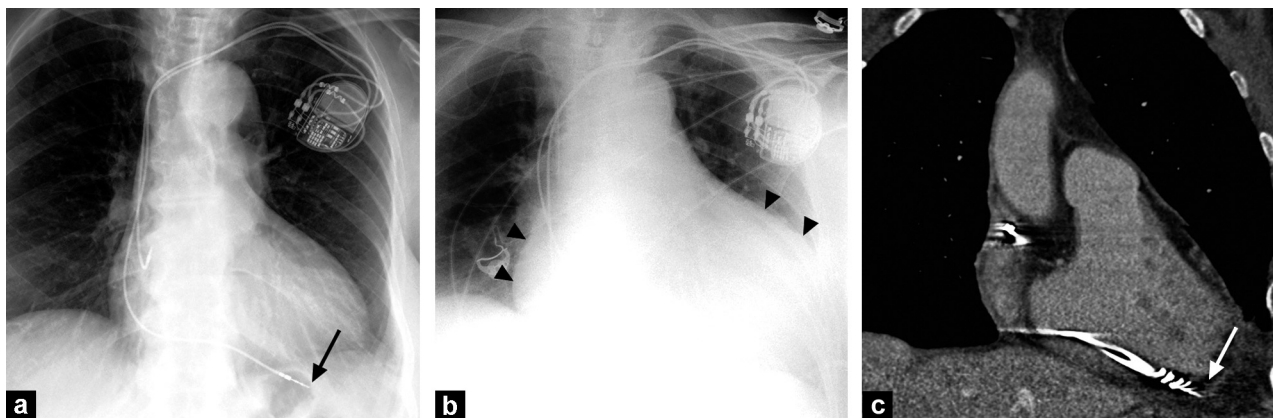
pericardial effusion, although these may not be present. The classical lead positions are well known and reported: the tip of the right ventricular lead projecting into the apex of the right ventricle, the atrial lead projecting into the right atrium and specifically into the right auricle and the left ventricular lead projecting along the path of the coronary sinus and one of its branches [11,12]. To our knowledge, there are no more specific criteria than “unusual” lead site to suggest malposition on the chest X-ray [10–12]. It is therefore essential to compare the investigation with previous X-rays and particularly with the post-procedure view in order to look for any change in lead position.

The site of the displaced lead can be better identified by CT, ideally carried out with cardiac synchronization and images reconstructed in diastole [10]. Myocardial penetration should be suspected if the tip of the lead passes up to 3 mm into the epicardial fat and if it is located entirely in the epicardial fat, myocardial perforation is very likely to be present [10]. In the same way as for standard X-rays, films should be examined for a pleural or pericardial effusion. Interpretation is often hindered by metal artifacts from the lead and requires an appropriate windowing for detection. The average attenuation value of electrostimulation materials is around 3000 HU [13], but to our knowledge, no study





**Figure 3.** Asymptomatic 62-year-old male patient (patient 3): a: chest X-ray at the patient's bedside showing the tip of the temporary lead projecting into the apex of the heart (arrow); b: incidental finding of perforation of the apex of the right ventricle in the pre-procedure cardiac CT angiogram, with displacement of the lead more than 6 cm outside of the heart. The tip of the lead has come into contact with the diaphragm on MIP reconstructions (arrow); c: 3D reconstructions of the cardiac perforation by the lead.



**Figure 4.** Sixty-nine-year-old woman with general condition worsening, abdominal pain and dyspnea (patient 4). a: post-procedure, postero-anterior chest X-ray showing no complications apart from an unusually low projection of the tip of the ventricular lead (arrow); b: chest X-ray in the emergency department showing enlargement of the cardio-mediastinal shadow with a globular appearance (arrowheads); c: cardiac CT angiogram performed a week later confirming myocardial perforation by the right ventricular lead, the tip of which has entered the epicardial fat by more than 8 mm (arrow). Note the lack of recurrence of the pericardial effusion after pericardiocentesis.

has sought to examine the optimal windowing in a chest CT in patients with cardiac pacing leads. From our own experience, unfortunately, there is no optimal window to visualize the electrostimulation materials as the artifacts generated remain present regardless of the center and width of the window. The only advice we can give to radiologists is to maintain the center of the window such that soft tissues can be visualized usually at +50 HU and that the width of the window be increased in order to reduce the blurring produced by metal artifacts from the leads. Empirically, therefore, a width of approximately 1200 HU has for example enabled us to moderately reduce these artefacts but not to abolish them completely. It is possible that the spectral CT may reduce the metal artefacts and therefore improve detection of these malpositions or displacements. The use of multi-energy should confirm its exact site by limiting artefacts at the tip of the lead particularly when it is located in the deep epicardial fat, a few millimeters from the epicardial surface. There are currently no data in the literature about these specific cases and a prospective study should be undertaken to define the role of multi-energy in reducing artifacts from pacing materials [14].

There is no consensus on the management of displaced leads and the perforations they cause, particularly when they are asymptomatic. However, explantation of the lead is the first option [15]. This has a mortality rate that ranges between 0.4 and 0.8%, but appears to carry a greater risk than that of a defective non-infected lead. The alternative is to disconnect the old lead and sheathe it. This appears to have a major complication rate similar to that of explantation, but a lower rate of minor complications. The main disadvantage of this approach is the possibility of interference between the old lead left in place and the new implanted lead.

The choice of procedure or decision not to intervene but opt for regular monitoring requires a specialist opinion. Suspected perforation on CT in asymptomatic patient is not enough on its own to justify removing the lead [8].

Based on these clinical cases we have reviewed the diagnostic difficulties which cardiac perforations from lead displacement raise, particularly when they occur late after implantation. As clinical findings are relatively non-specific or even absent, radiologists should always examine the path of leads in any patient with an implanted cardiac device. To do this, it is essential to compare the chest X-ray with previous X-rays and particularly with the first investigation post-implantation. To our knowledge, however, there are no more specific criteria than an unusual site of the leads, which suggest that they are mal-positioned on the chest X-ray. From our own experience an unusually caudal site on the posterior anterior film or anterior site on the lateral film of the tip of the right ventricular lead should suggest myocardial perforation and warrants additional CT investigation, which should ideally be carried out with cardiac synchronization and reconstructions in diastole. The radiologists should pay attention to the position of the tips of the leads with respect to the epicardial fat on CT, although unfortunately, there is no optimal density window to visualize pacing materials and the artefacts produced persist regardless of the

window chosen. The possible role of spectral CT in reducing artefacts from these leads and how well it performs in locating leads precisely, still need to be demonstrated in the future.

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

## References

- [1] Welch AR, Yadav P, Lingle K, Linton-Frazier L, Haouzi A, Wolbrette D, et al. Subacute right ventricular pacemaker lead perforation: often talked about in consent forms but very rarely seen. *J Innovations Cardiac Rhythm Manag* 2011;2:442–5.
- [2] Haute Autorité de santé (HAS), Service évaluation des dispositifs. Stimulateurs cardiaques conventionnels – place respective des stimulateurs simple et double chambre – révision de la nomenclature inscrite à la liste des produits et prestations remboursables; 2009 <http://has-sante.fr>
- [3] Haute Autorité de santé (HAS), Commission d'évaluation des produits et prestations. Défibrillateurs cardiaques automatiques implantables – avis de la commission; 2007 <http://has-sante.fr>
- [4] Centre fédéral d'expertise des soins de santé (KCE). La stimulation cardiaque chez les patients bradycardes en Belgique. KCE reports 137B; 2010 <http://kce.fgov.be>
- [5] Centre fédéral d'expertise des soins de santé (KCE). Le défibrillateur cardiaque implantable : un rapport d'évaluation de technologie de santé. KCE reports 58B; 2007 <http://kce.fgov.be>
- [6] Ellenbogen KA, Wood MA, Shepard RK. Delayed complications following pacemaker implantation. *Pacing Clin Electrophysiol* 2002;25:1155–8.
- [7] Celik T, Kose S, Bagan B, Ilysoy A, Akgun V, Cingoz F. Hiccup as a result of late lead perforation: report of two cases and review of the literature. *Europace* 2009;11:963–5.
- [8] Hirschl DA, Jain VR, Spindola-Franco H, Gross JN, Haramati LB. Prevalence and characterization of asymptomatic pacemaker and ICD lead perforation on CT. *Pacing Clin Electrophysiol* 2007;30:28–32.
- [9] Mak GS, Truong QA. Cardiac CT: imaging of and through cardiac devices. *Curr Cardiovasc Imaging Rep* 2012;5:328–36.
- [10] Aguilera AL, Volokhina YV, Fisher KL. Radiography of cardiac conduction devices: a comprehensive review. *Radiographics* 2011;31:1669–82.
- [11] Lanzman RS, Winter J, Blondin D, Fürst G, Scherer A, Miese FR, et al. Where does it lead? Imaging features of cardiovascular implantable electronic devices on chest radiograph and CT. *Korean J Radiol* 2011;12:611–9.
- [12] Bejvan SM, Ephron JH, Takasugi JE, Godwin JD, Bardy GH. Imaging of cardiac pacemakers. *AJR Am J Roentgenol* 1997;169:1371–9.
- [13] Halpern BS, Dahlbom M, Waldherr C, Yap CS, Schiepers C, Silverman DH, et al. Cardiac pacemakers and central venous lines can induce focal artifacts on CT-corrected PET images. *J Nucl Med* 2004;45:290–3.
- [14] Yu L, Leng S, McCollough CH. Dual-energy CT-based monochromatic imaging. *AJR Am J Roentgenol* 2012;199:S9–15.
- [15] Agence française de sécurité sanitaire des produits de santé (Afsaps). Risques liés à l'implantation des DMA de cardiologie : données bibliographiques; 2012 <http://ansm.sante.fr>